Kāpiti Water Supply

Ranked Options - Summary Report

6th August 2010

Prepared for Kāpiti Coast District Council by CH2M Beca

Project Sponsor	Pat Dougherty
Project Manager	Phillip Stroud
Report Editor	Greg Pollock
Contributors	Nicky Egyed, Kirsten Mandeno, Andrew Watson, Greg Pollock, Nathan Baker, Nikita Bazalo, Phillip Stroud
Acknowledgements	Technical Advisory Group Dam Watch Wildlands NIWA Nimmo Bell
Approved for release by	Andrew Watson

Executive Summary

Providing a reliable water supply for the Waikanae, Paraparaumu and Raumati (WPR) communities that is sustainable and will meet the expectations of consumers is a fundamental issue for Kāpiti Coast District Council (Council). The existing water supply is under stress in terms of its capacity to meet the peak water demand in summer. The purpose of the Kāpiti Water Supply Project is to identify the most suitable solution for providing water to meet the communities' needs for the next 50 years. The aim is to find a solution that provides the required amount of water by 2060 – that is, 32,000 m^3/day – up from the currently consented limit of 23,000 m^3/day.

This report summarises and evaluates four options from within the Waikanae River catchment (i.e. in-catchment options) that have been investigated in Stage 3 of the Kāpiti Water Supply Project. The evaluation took into account community feedback on the options, and Resource Management Act requirements.

The four options are:

- Option 1 - Lower Maungakotukutuku Dam
- Option 2 - Borefield and Treatment
- Option 3 - Aquifer Storage and Recovery
- Option 4 - River Recharge with Groundwater

For the purpose of comparison with the four in-catchment options, designs and cost estimates have been completed for two options that involve sourcing water from the Ōtaki River. Both Ōtaki options were more expensive than three of the four in-catchment options. There is also a lack of support for these options from the Ōtaki community and tāngata whenua. Furthermore, the Ōtaki River's ability to meet the demand for WPR, once minimum flows are considered, is uncertain. All of these factors leads to this report rejecting the Ōtaki River options.

Ranked Options

The ranking of the four in-catchment options, included consideration of a number of advantages and disadvantages of each option, including security of supply and water quality as well as the likely construction costs and the total operation and maintenance costs over a 50 year period. The final ranking is presented in the following table.

Table 1: Ranked Options

Rank	Option
1	River Recharge with Groundwater
2	Lower Maungakotukutuku Dam
3	Aquifer Storage and Recovery
4	Borefield and Treatment

This report includes a number of recommendations. However, two key recommendations relate to the preferred option and the need to consider the longer term security of water supply beyond the next 50 years. A summary of the two key recommendations are:

- That Council proceed with River Recharge with Groundwater as the preferred solution, and undertake the further steps outlined in this report to confirm feasibility
- That Council future-proof the WPR water supply for the long term (e.g. 50-100 years) by securing ownership for the Lower Maungakotukutuku dam site and resolving any constraints to development of a dam on that site in the long term.

Detailed rationale for these recommendations is included in this summary report. This report should also be read in conjunction with the Technical Analysis Report and related appendices.

Contents

1 Introduction

Providing a reliable water supply for the Waikanae, Paraparaumu and Raumati communities that is sustainable and will meet the expectations of consumers is a fundamental issue for Kāpiti Coast District Council (Council). The existing water supply is under stress in terms of its capacity to meet the peak water demand in summer. The purpose of the Kāpiti Water Supply Project is to identify the most suitable solution for providing water to meet these communities' needs for the next 50 years. The aim is to find a solution that can be in place by 2015, as there is a risk that within the next five years population growth and high water consumption could result in demand that exceeds the Council's currently consented limit for water abstraction of 23,000 m^3/day.

Council is also addressing other issues relating to water management by implementing the Water Matters Strategy, including a range of measures to improve water conservation across the district.

Sustainable management of natural and physical resources, including water resources, is a key factor in the Council's decision making process. Fourteen principles of sustainable management are detailed in the Long Term Council Community Plan (LTCCP). The Council's Water Matters Strategy also specifies that as a first preference, water supply be from in-catchment sources. For the Waikanae-Paraparaumu-Raumati (WPR) catchment this effectively means that the water source is either the Waikanae River surface water catchment or groundwater on the coastal plain.

The options presented in this report were identified following two previous stages of option identification and analysis. This involved:

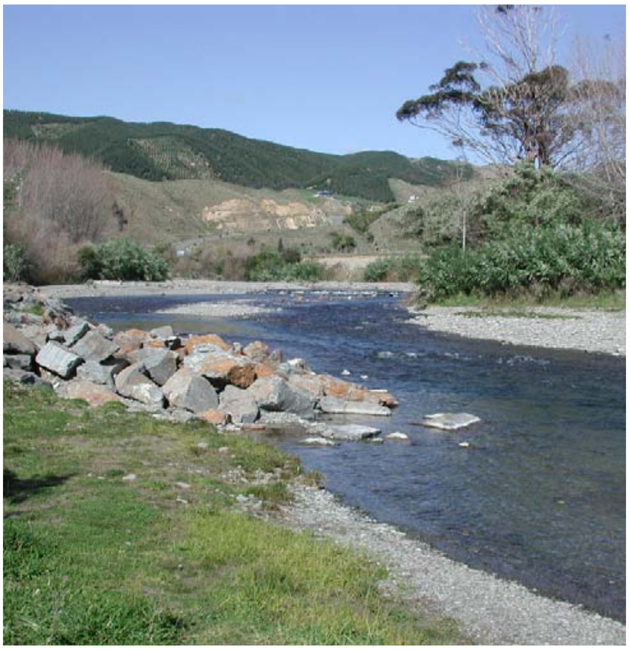
- Stage 1: A review of 40 options (Preliminary Status Report) which included all options developed by Council in the preceding years, and a number of new options to ensure every possible option was explored and evaluated. This report narrowed the list down to 31 options, with 9 being eliminated due to insufficient yield, excessive cost or major technical or consenting difficulties. This report was tabled with Council on 17th December 2009.
- Stage 2: An evaluation of all 31 options was based on the values the wider community identified as being important in making a decision on water supply. Further investigations into each of the 31 options eliminated a further 11 based on yield, cost or other technical difficulties. A multi-criteria assessment was carried out on the remaining 20 options. The criteria were strongly informed by the results of community consultation and technical knowledge of each option. At this time, there was a strong view from the Ōtaki community that water from the Ōtaki River should not be considered. When this view was considered alongside Council policy which was to favour in-catchment solutions in the first instance, Ōtaki options were placed on hold while Council undertook further consultation with that community. The Option Selection Report therefore recommended a short-list of six in-catchment options that was adopted unanimously by Council on 11th March 2010.

- **Stage 3:** The aim is to present a ranked list of options, and to recommend a preferred solution. Over the course of this stage, there were two developments that are important to report here for context:
  - At the conclusion of Stage 2, Ōtaki River source options were not pursued further due to Council's policy preference for in-catchment sources, and also local community concerns. However, in order to ensure that Council has sufficient information in front of it to make the best decision possible, two of the Ōtaki options have been designed and costed to the same degree of detail as the six in-catchment options. The Ōtaki options have not been investigated in terms of environmental or other effects/risks. While consultation has occurred with the Ōtaki community in general terms, there has been no specific consultation in relation to these options in this stage of the project. The Ōtaki Community Board has sent a clear signal to Council that the Ōtaki community does not support any option involving abstracting Ōtaki River water. These options were costed purely to inform Council, and are presented in this report for comparison purposes
  - In addition, as investigations occurred into each of the six in-catchment solutions, some options were eliminated. The Ngātiawa Dam and Kapakapanui Dam, as well as two variations of the Borefield and Storage/Treatment option were eliminated as a result of an interim report adopted by Council on 24th June 2010. These options were going to be significantly over the capital budget Council identified. Therefore, four in-catchment options remain.

The full engineering design, technical and environmental investigations and consultation results for all six options, including those placed on hold earlier, is included in the *Ranked Options – Technical Analysis Report.* This report focuses on the four remaining options, from which a preferred solution is identified and recommended to Council for consideration.

The four options are:

- Option 1: Lower Maungakotukutuku Dam [1]
- Option 2: Borefield and Treatment
- Option 3: Aquifer Storage and Recovery
- Option 4: River Recharge with Groundwater



In addition to these four options, it is possible that the 'best' aspects of one option could be combined with the 'best' of another in order to deliver a superior option. This report also presents these ideas as 'composite' options.

1.1 Purpose of Report

This report has been prepared as a companion to the Stage 3 *Ranked Options - Technical Analysis report*. The purpose of this report is to:

- Provide an overview of the process used to develop the ranked list of options, including options previously eliminated
- Summarise the four remaining options including the outcomes from technical investigations, design work and extensive consultation that have occurred in this stage of the project
- Provide an overview of two Ōtaki River source options that have been designed and costed for comparison purposes only
- Present the cost estimates in a manner that fully informs decision-makers
- Consider composite options
- Evaluate and rank the short-listed options
- Recommend a preferred solution and the next steps for the project.

[1] *In the Ranked Options – Technical Analysis Report the options are referred to as Option B, D2, E and F, respectively*

2 Overview

This section provides an overview of the technical investigations, consultation, design requirements and cost estimates work that has been undertaken in Stage 3. It is noted that whichever option is chosen, there will likely be further investigations, design and consultation required

2.1 Technical Investigations

Stage 3 has focused on developing concept designs for each option, supplemented by technical investigations which have included:

- Geotechnical investigations and drilling at Lower Maungakotukutuku dam site
- Surface water yield modelling for the Waikanae River catchment to determine yield from the run-of-river abstraction, required storage volumes and required groundwater yield. The preliminary modelling was based on a peak day yield of 32,000 m^3/day, the 2007/2008 demand profile, the 2002-2006 Waikanae River flow records adjusted to reach a 50 year low flow and a core river allocation of 26,000 m^3/day
- Pump testing of 3 bores within the existing Waikanae Borefield and groundwater modelling to determine the sustainable yield and overall performance of the borefield (current and extended)
- Investigation of terrestrial ecology by Wildland Consultants
- Investigation of in-stream ecology by NIWA, including monitoring impacts of discharging bore water to the Waikanae River
- Review of the existing Waikanae Water Treatment Plant (WTP) and treatment options required for different water sources
- Water taste testing of different water samples, including bore water subjected to treatment methods (nanofiltration, lime softening, blending bore and river water)
- Preliminary examination of planning/regulatory requirements and the potential range of environmental effects that would need to be considered for the preferred option.

Over the course of the project, the technical investigations have been subject to peer review by a Technical Advisory Group (TAG), as well as review by officers at Council. The TAG is comprised of a range of legal, scientific, engineering and another professionals who live locally within the District, who have volunteered their time to assist Council in coming to a preferred solution. Beca have met with the TAG regularly over the course of Stage 3 to present results of the investigations, and identify areas of risk, further investigation or other opportunities to provide the best solution. The TAG will issue a separate report containing their advice to Council.

2.2 Community Consultation

During the course of the Kāpiti Water Supply Project there has been a great deal of community consultation. This has occurred in previous stages at the generic level in terms of the values that are important to the community, and in this current stage of the project, in relation to specific options and their potential effects. Running hand-in-hand with the Water Supply Project, Council's water conservation initiatives have also been widely consulted on and form an important component of the overall water management framework.

The results of community consultation in relation to the four options are provided later in this report, however, understanding the key messages from the wider community are important to set the context.

Overall, the key community messages from Stage 3 consultation remain consistent with the outcomes of the early rounds of consultation in terms of the key values of water quality, security of supply and cost, summarised as follows.

- Water quality – The taste of water that is abstracted from the Waikanae River is generally acceptable to the WPR community. When the supplementary borefield supply is used, the quality changes from a 'soft' to a 'hard' water, and the 'saltiness' taste increases. The hardness of the bore water has remained a key concern. There is a proportion of the community that is reluctant to support the ongoing use of the borefield for potable water supply. Should the borefield continue to be relied on for potable water supply, treatment or blending of the bore water to reduce the hardness needs to be allowed for
- Security of supply – With a growing population, having a reliable supply that can deliver water during a drought is important to the community. The supplementary borefield has been used on a number of summer occasions to ensure that the minimum river flow level set by Greater Wellington Regional Council is met. The Waikanae River cannot be relied on to provide the full future demand
- Cost – The water supply option must be affordable and value for money. Stage 3 consultation has shown a strong level of community interest in cost, particularly comparative costs (both construction and operational) between the six short-listed options. There is also some interest in the reasoning for the $23M budget and whether the higher cost options (dams) will be able to fit within that

In addition, consultation from Stage 3 has provided feedback at a more detailed level. Key community messages in this regard include:

- Process – All feedback on consultation process has assisted the project team to focus consultation efforts and ensure a coherent and commonsense process to systematically build a case towards a preferred solution. In terms of process, there is overall support for the investigation of in-catchment options as a first priority before looking to out-of-catchment options. Positive feedback has been received regarding the role of the Technical Advisory Group in the option investigation and selection process, particularly in terms of using local knowledge to inform decisions and review the technical investigations
- Partnership approach with tāngata whenua – Council continues to build a partnership approach with tāngata whenua in relation to water management, based around the core values of kaitiakitanga, tino rangatiratanga, tāonga, mauri and whakapapa. The focus on in-catchment options as a first priority is a strong indication that Council is taking into account these core values, and this is supported by the tāngata whenua of Ōtaki (Raukawa). Council is working closely with the Te Āti Awa as tāngata whenua in the WPR, in the spirit of the Memorandum of Understanding being developed for this project, particularly with the Te Āti Awa Water Working Group in the investigation of cultural impacts of whichever preferred solution is identified. At this stage, tāngata whenua have not identified any fatal flaws with any of the four options
- Water conservation – The conservation target of 400 litres/person/day forms a fundamental design assumption for the water supply project. The importance of water conservation has been an ongoing theme during the community consultation for this project, with both Council and the community raising a range of methods to achieve lower consumption rates of potable water.

Key messages in relation to the options are summarised in the Section 3 under the specific option.

2.3 Design Requirements

The Kāpiti Water Supply Project has a number of design requirements, which are:

- The solution must be able to meet the design demand in a drought with a 1 in 50 year return period (i.e. 2% probability of occurring in any one year).
- The design peak day demand for 2060 is 26,000 m^3/day on the basis of the following:
  - 400 L/person/day peak day consumption (incorporating commercial/industrial demands)
  - Unaccounted for water (losses) of 90 L/person/day
  - Population growth (and matching increase in demand) at the medium-growth scenario
- The design peak day yield from the particular water source(s) is 32,000 m^3/day, which allows for headroom of 6,000 m^3/day on the design demand
- The quality of the treated water delivered to consumers must meet the following requirements:
  - Compliance with the Drinking-water Standards for New Zealand 2005 (revised 2008)
  - Taste, odour and aesthetic qualities must be acceptable to most consumers
- If groundwater is blended or treated – a target treated water hardness of ≤ 80 mg/L (as $CaCO_3$), sodium of ≤ 200 mg/L and total dissolved solids of ≤ 500 mg/L.

The design requirements are focussed on providing supply for the next 50 years for the WPR area. However, there are a number of underlying assumptions. Given the range of variables (e.g. growth rates, water conservation, climatic patterns), it is possible that the design peak daily yield of 32,000m^3/day which is estimated to be required by 2060, could be required much sooner, or much later.

Overall, at some time in the future, an additional water supply source will be required for WPR. 'Future-proofing' the WPR supply for such a time is not a specific aspect of the current project, but should be considered if the opportunity can be taken at reasonable cost and if budgets permit.

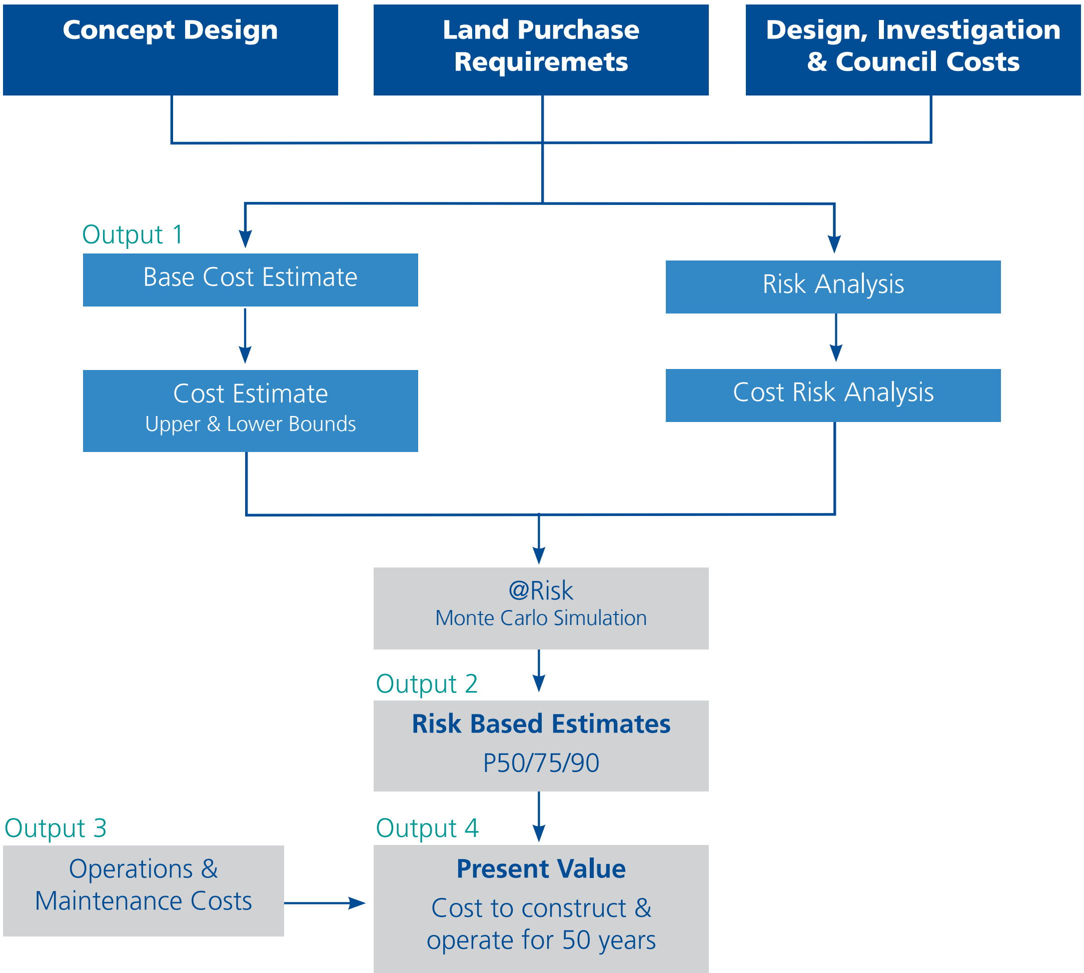
2.4 Cost Estimates

Cost is one of a number of key factors in making the decision on a preferred solution for the Kāpiti Water Supply project. In this report, four different types of cost estimate are provided to Council to assist in decision making. These are:

- Output 1: Base capital cost – These estimates are comprised of a number of elements, including
  - Professional costs - Fees and Investigation Costs - The cost of investigations to date, plus an allowance for future consulting, legal and investigation fees, as well as Council internal costs, up to and including gaining resource consent for that option.
  - Land purchase costs
  - Construction cost
  - Design and management – The resource consent process only requires a preliminary design in order to gain consent. While the consenting authority may seek some further information in relation to the design through the consent process, the detailed design and construction management for the preferred option would typically follow grant of resource consent. Council will then have a number of options as to how detailed design occurs, that would be considered as part of an overall procurement strategy. However, at this stage a budget of 12% of the capital cost is estimated for design and management of the construction process. There is also an allowance for Council internal costs during this period.
  - Contingency allowance - This is included at 25% of the capital cost. This contingency reflects the early stage of development of the engineering design.
- Output 2: Risk based cost estimates – These are explained and detailed later in this report
- Output 3: Operations and Maintenance costs – These estimates provide an indication of the likely cost to operate and maintain each of the options over a year. This estimate includes Council's presents water source and treatment costs. The O&M costs provide a key input to preparing the present value estimates
- Output 4: Present value costs – The results of the analysis are presented as the present value (PV) of each option at the expected value derived from a risk analysis along with the probability distribution of the PV.

The following diagram provides an indication of how and where these costs were generated:

Figure 2.1: Costings flow chart



3 Options

The process of identifying and analysing options started in Stage 1 with an extensive review of 40 different options. Options have been analysed against a range of criteria identified from community consultation and the design requirements for the project. The four remaining options presented in this section are considered in terms of the design approach, any land requirements for the option, environmental investigations undertaken, consultation and finally the cost estimates developed to assist in comparative analysis and decision making.

It should be noted that in this section of the report, the base capital cost estimates are provided as a general guide as to cost. Later in the report, more robust 'risk-based' cost estimates are provided.

Figure 3.1 shows the location of each of the four options, and the existing Waikanae Water Treatment Plant.

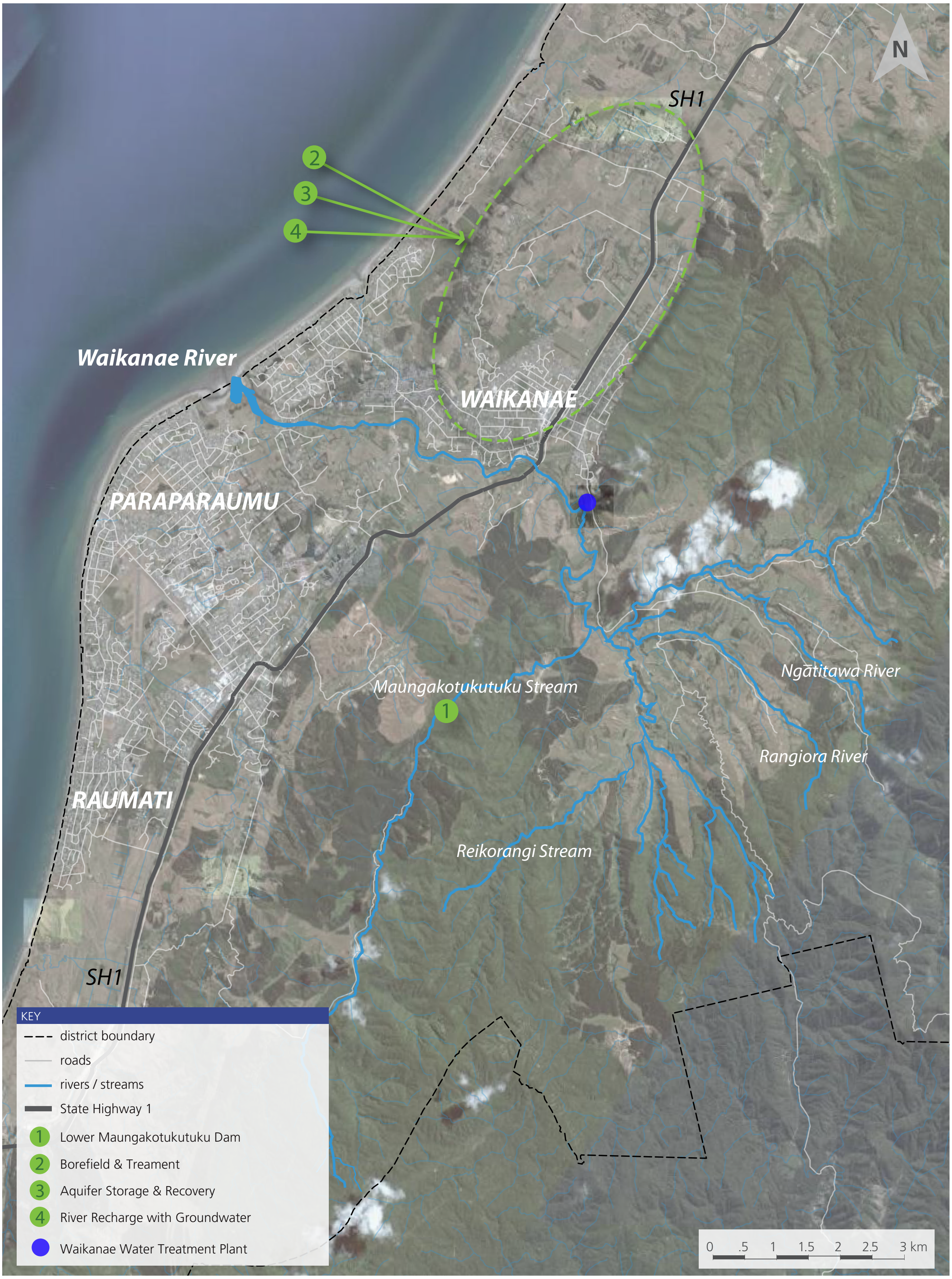


Figure 3.1: Location of four options

3.1 Option 1 – Lower Maungakotukutuku Dam

3.1.1 Location

The proposed Lower Maungakotukutuku Dam is located on the Maungakotukutuku Stream, a tributary of the Waikanae River in the western part of the river catchment. The dam site is located where the valley narrows to a gorge downstream of a wider valley section, approximately 3 km upstream of the confluence of the Maungakotukutuku Stream with the Waikanae River. The dam site can be accessed from the Nikau Valley subdivision.

3.1.2 Geotechnical Investigations

Walkover and test pit inspections of the site, and an investigatory drilling programme were carried out to determine the suitability of the location. The results confirm that there is no evidence of active faulting through the valley at the dam site. Furthermore, the rock quality is well suited to the proposed dam design, and the valley slopes in the reservoir area show no signs of major instability. Overall, the investigations have confirmed that the site is suitable for the dam design that is described below, and that the cost estimate provided is appropriate to the geotechnical conditions found.

3.1.3 Design

A roller-compacted concrete dam is proposed for this site because of the reduced construction duration and cost when compared to conventional mass concrete dam construction. The close proximity of greywacke bedrock to found the dam on, locally available potential sources of greywacke rock suitable for concrete aggregate and the ability to incorporate the spillway within the dam structure influenced the selection of a concrete dam rather than an embankment dam. The dam would be 31.5 m high and provide a live storage volume of 1.9M m^3.

The design, construction and operation of the dam would have to meet prescribed standards. The Lower Maungakotukutuku Dam has been assessed as a Medium Potential Impact Classification (PIC) based on the potential for damage to the dam and the impacts that would occur if the dam were to release its reservoir contents [2].

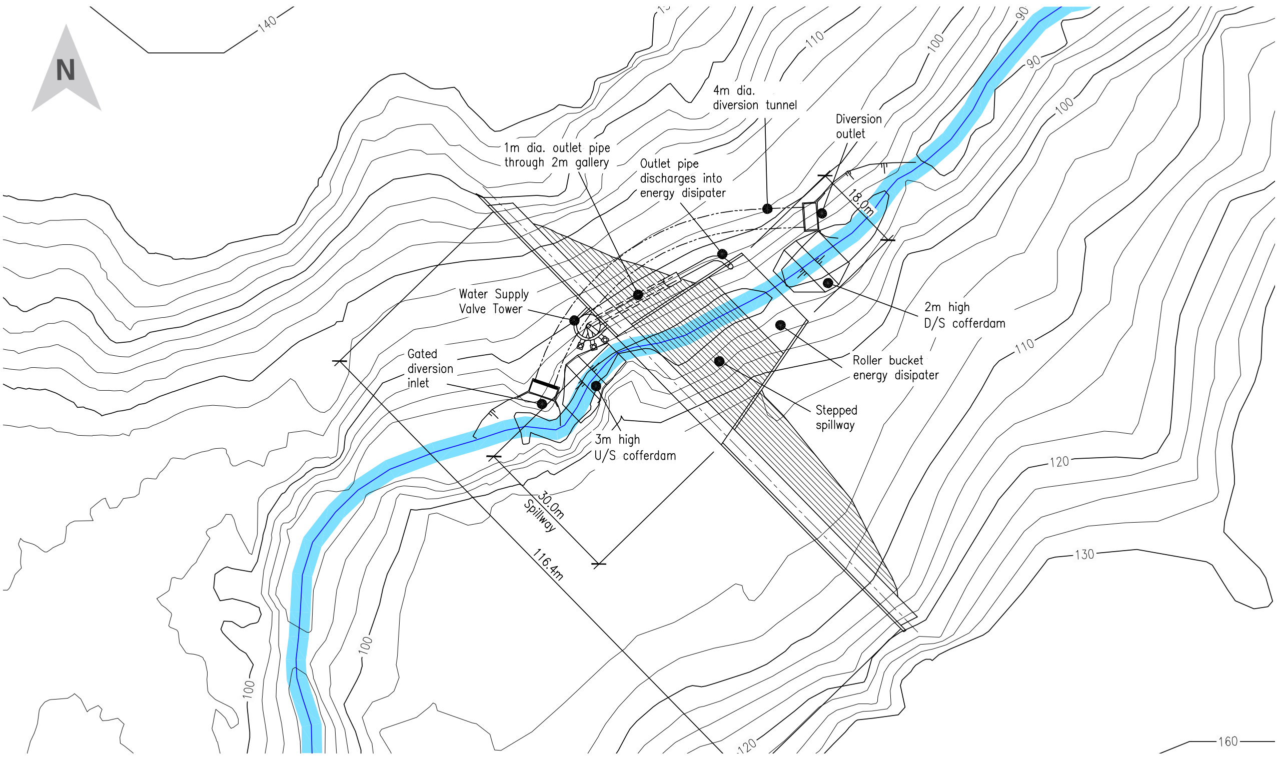


Figure 3.2: Lower Maungakotukutuku Dam Concept

[2] *For further information on dam design classification, visit: http://www.ipenz.org.nz/nzsold/GuidelinesMainText.pdf*

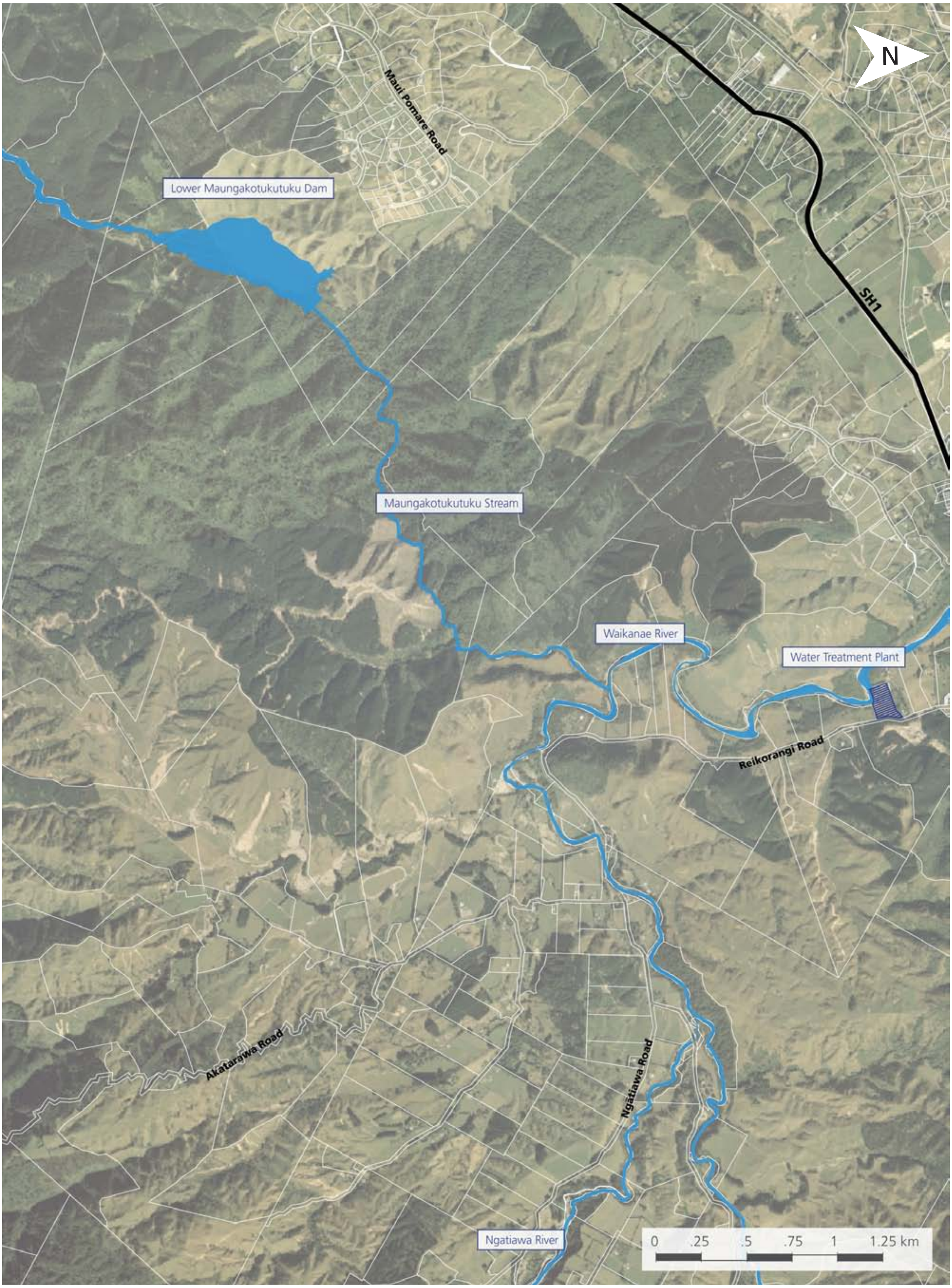


Figure 3.3: Lower Maungakotukutuku Dam

3.1.4 Yield

The preliminary yield modelling showed that in the modelled 50 year drought with the required peak day yield of 32,000 m^3/day, the dam would be called on for up to about 140 days in the drought year and the longest continuous period of dam use within that time would be about 60 days.

At times of low flows in the Waikanae River and/or high demand when the dam is needed for water supply, water will be released from the reservoir into the stream for abstraction at the existing water treatment plant intake. When the reservoir behind the dam is full, all of the flow into the reservoir will be spilled from the dam into the stream below. During times when the dam is not full there will be a minimum flow released from the dam to maintain a residual flow in the stream, except when inflows naturally fall below this minimum flow in which case the dam outflow would equal the dam inflow. It is not intended that the dam be used to increase flows in the Waikanae River downstream of the water treatment plant.

3.1.5 Land

There are two main landowners directly affected by this dam. Both landowners are generally supportive of the dam. There are site specific matters to be addressed, including site access and providing for the ongoing operation of farming and forestry activities on site. Some general community concern has been raised regarding dam break risk and environmental effects of damming the stream, as well as traffic impacts during construction.

3.1.6 Environmental

NIWA investigated in-stream communities of the Maungakotukutuku Stream. Six fish species were found, the most common of which were longfin eels and redfin bullies. The fish fauna appears typical to that of other rivers in the area. The invertebrate community was dominated by invertebrates indicative of streams in good-excellent condition, with low nutrient water. Community composition changed little along the stream, so loss of a section of stream as a result of creating the dam will not necessarily reduce the invertebrate biodiversity values of the whole stream.

There will be a total loss of river habitat along the length of the reservoir, displacing fish such as redfin bullies, torrent fish and koaro, and invertebrates from the flooded stream. Other fish species such as trout, giant kokopu and eels, however, can tolerate lentic (standing water) conditions. The dam would potentially disrupt movement of native fish to and from the sea, but this can be mitigated by providing upstream and downstream fish passage.

An 18 ha area of land within and adjacent to the dam site has been covenanted under the Reserves Act and is administered by the Department of Conservation. Approximately 4.41 ha of this covenant would be inundated or affected by construction works. The approval approach/options for the covenanted area will need to be investigated with the Department of Conservation in further detail if the Lower Maungakotukutuku Dam option is preferred. There are mitigation measures that could be implemented to off-set the loss of this vegetation.

The total reservoir inundation area is 28 ha and most of the area proposed to be flooded is primarily pasture or exotic plantation forest, with 79% of the area having low or low-moderate terrestrial ecology value.

One of the risks for this option is algal blooms in the reservoir as the water is not particularly deep across the whole of the reservoir area due to the topography of the site. This risk can be mitigated with reservoir management and additional treatment at the water treatment plant which has been allowed for in the design concept and cost estimates.

3.1.7 Consultation

In general, the concept of a dam as a water supply solution appears to have general support in the community. However, concern has also been expressed by some residents immediately downstream of the potential dam sites. Those noting support for dam options talk of the benefit of the certainty of a tried and tested concept and of capturing rain water sensibly in the hills. Those noting opposition talk of the risk of dam break and adverse environmental effects, particularly to in-stream ecology and amenity. This dam site is located within a conservation covenanted area, and there are specific issues to be addressed around the inundation of significant vegetation and habitat.

3.1.8 Cost Estimates

The base capital cost estimate for this option is $27.9 million (refer table below).

Table 3-1: Lower Maungakotukutuku Dam Base Capital Cost Estimate

	Cost
Council costs, fees & Investigation [3]	$2.65M
Land Value [4]	$1.29M
Capital Cost	$16.58M
Design and Management [5]	$2.59M
Contingency (25%)	$4.79M
TOTAL	$27.9M

The operational and maintenance costs for this option are estimated at $1.36M/year increasing to $1.49M/year in 50 years.

[3] This provisional figure is based on the fees to date, plus estimated fees to completion of RMA approvals ($1.7M). In addition, allowance is made for internal Council costs ($650,000), plus further geotechnical investigations carried out during Stage 3 ($120,000), legal fees for Council hearings (est. $100,000), plus Greater Wellington and Council processing costs (est. $100,000)

[4] This figure is based on the cost of buying the area necessary for the dam footprint, associated access, and the inundation area of the reservoir, plus a buffer area around the reservoir. It also includes Emission Trading Scheme (ETS) costs and off-setting an area of native forest of equivalent conservation value

[5] Includes an allowance for Council internal costs

3.2 Option 2 – Borefield and Treatment

3.2.1 Concept

This option involves extending the existing Waikanae Borefield to provide water for the WPR supply at times when the run-of-river abstraction from the Waikanae River is limited by drought. The existing borefield draws water from the Waimea aquifer during these low flows. This option is similar to the current set-up except that the capacity of the groundwater supply is extended by adding new bores to cater for growth in demand and there would be additional treatment of the bore water to better match the quality required.

The current bore water supply is unacceptable to the community due to water hardness and taste concerns. To address these issues, a portion of the bore water would be treated in a nanofiltration plant located within the Waikanae WTP site. Nanofiltration is a membrane process that effectively removes the calcium and magnesium ions that cause water hardness. The nanofiltration plant would treat only about half of the bore water to meet the design requirements for treated water quality.

A by-product of nanofiltration is brackish reject water which requires disposal – this effectively means this option requires approximately 10% more water to account for this loss. The most economic solution would to send it to the Paraparaumu Wastewater Treatment Plant via a new pipeline from the WTP for co-discharge with the existing effluent from the wastewater treatment plant into the Mazengarb Drain (it does not need to be treated by the plant). A provisional volume for reject water is 3,300 m^3/day. At this stage, there has been no investigation of the potential impacts of this additional volume of waste on the Mazengarb Drain.

During the investigation phase, the groundwater model identified potential concerns relating to saline intrusion in the aquifers. In order to avoid this, the design approach was refined to include injection to the Waimea aquifer.

3.2.2 Design of Borefield

The current Waikanae Borefield was designed to supply up to 23,000 m^3/day. Therefore, the borefield would need to be extended in order to meet the future peak day demand and allow for the quantity of reject produced by the nanofiltration plant. The concept design includes four new bores, provisionally located north east of the existing borefield on the eastern side of Stage Highway 1. The alluvial aquifer widens to the north of the WTP and narrows towards the south. The locations for these new bores were chosen based on the following criteria:

- At least 3000 m from the coastline to minimise the risk of saline intrusion
- Spacing of 500 m between wells to reduce interference effects
- Wells being in a line perpendicular to the groundwater flow direction to minimise interference effects between production wells.

The construction of the full extended borefield scheme could be staged over the next fifty years to match demand.

The bores have been located adjacent to roads to minimise disruption to private landowners. The exact location and number of bores would be selected based on investigation bores, in-situ tests and consultation with potentially affected landowners. The new bores and wellheads would be similar in design to the existing bores within the Waikanae Borefield. If necessary, the wellhead can be constructed within a below ground chamber. A new pipeline would be constructed from the new bores to the Waikanae WTP site.

To mitigate risks around saline intrusion, allowance has been made for a new pump station at the Water Treatment Plant site to transfer river water during winter and spring to the Waikanae Borefield (via the existing pipeline) for recharging the aquifer. Three of the existing bores would be modified to enable them to be used for recharge as well as abstraction.

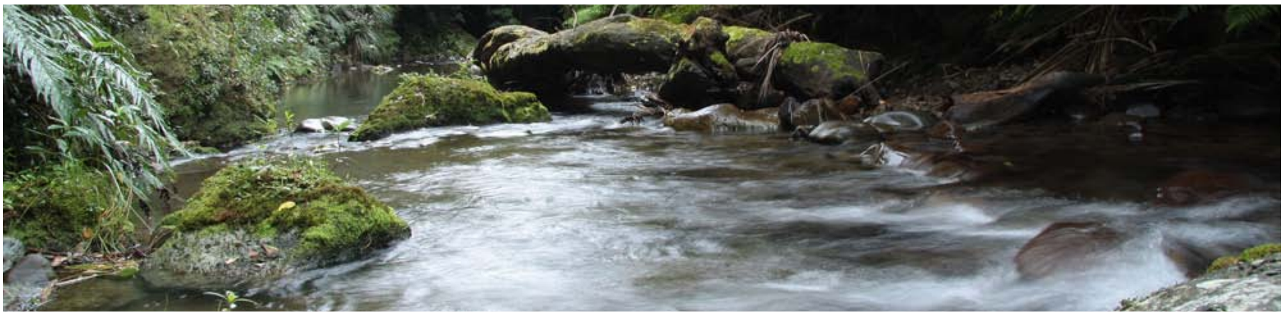


Figure 3.4: Borefield and Treatment

3.2.3 Yield

The yield modelling showed that in the modelled 50 year drought with a required peak day yield of 32,000 m^3/day, the bores would be needed for up to about 140 days in a year and the longest continuous period of bore use would be about 60 days.

The groundwater modelling has shown that the saline intrusion is avoided if up to 10,000 m^3/day is injected into the aquifer for 5 months.

3.2.4 Environment

The in-stream ecological effects of this option on the Waikanae River should be no different to the current water supply scheme. Extending the borefield and increasing the amount of groundwater extracted from the aquifer is not expected to adversely affect flows in the Waikanae River.

The impacts of brackish water discharge (nanofiltration plant reject) when co-discharged with the WWTP effluent into the Mazengarb Drain has not been considered to date. It will need to be investigated in detail if this option is carried forward (including whether there are adverse effects on the bank erosion that has been an historical problem along the drain).

Few, if any, adverse terrestrial ecology effects are expected with this option. The groundwater modelling has shown limited impacts on the shallow aquifer, allaying any concerns over the potential for adverse effects on wetlands and indigenous wet forest dependent on the aquifer.

3.2.5 Consultation

Although no fatal flaws have been raised in terms of landowner or stakeholder concerns, there is a general reluctance by many in the community to continue to rely on the borefield for potable water supply due to water quality (taste and hardness). It is anticipated that this option may have difficulty gaining the support of the community without a clear understanding of how the additional treatment will address the issues of taste and hardness.

3.2.6 Cost Estimates

A breakdown of the base capital cost estimate for this option is $34.3 million (refer table below).

Table 3-2: Borefield and Treatment Capital Cost Estimate

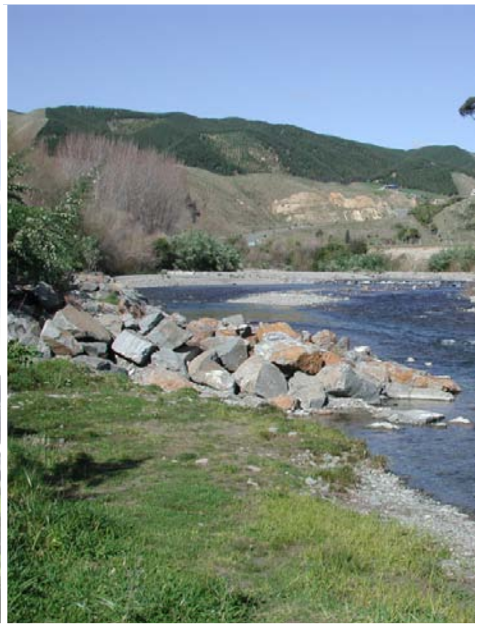
	Cost
Fees & Investigation [3]	$2.65M
Land Value	$0.07M
Capital Cost	$22.01M
Design and Management [6]	$3.24M
Contingency (25%) [7]	$6.31M
TOTAL	$34.3M

Overall O&M costs for this option are estimated at $1.71M/year increasing to $1.89M/year in 50 years.

[3] *See page 13*

[6] *Includes an allowance for Council internal costs*

[7] *This option requires disposal of brackish reject water via the wastewater treatment plant discharge to the Mazengarb Drain. This will require additional consultant, design and investigations (including ecology) and potentially some additional attenuation pond storage if this option is pursued. It is considered that these costs are relatively minor and covered by the contingency*



3.3 Option 3 – Aquifer Storage and Recovery

3.3.1 Concept

The Aquifer Storage and Recovery (ASR) option involves injecting surplus water from the Waikanae River into the deep Waikanae aquifer (Waimea Aquifer) and recovering that river water for supplementing the river supply during summer when river flows are low.

New recharge bores would be constructed up-gradient of the existing Waikanae Borefield bores for injecting water into the aquifer in the winter and spring. The injected river water would displace the naturally occurring groundwater and the aquifer would act like an underground storage reservoir for the river water.

During times of low flow in the Waikanae River, when the abstraction from the river must be reduced to maintain minimum residual river flows, the stored river water would be abstracted from the aquifer via the existing bores and conveyed to the Waikanae Water Treatment Plant (WTP). The abstracted water would be treated in the existing treatment plant before being put into supply.

Although ASR is essentially an untried technique in New Zealand, it has been successfully used in the USA, Europe and Australia for drinking water supplies. The water used in these schemes for injection to the aquifer is typically surface water, stormwater or treated wastewater.

The following schematics illustrate the concept of ASR. In effect, the aquifer is used as an underground storage reservoir.

ASR offers the potential benefits of enhancing the sustainability of the aquifer and improving the quality of water abstracted from the aquifer for water supply.

3.3.2 Design

If there is surplus river water available and the aquifer can be, or needs to be, replenished, then a new pump station will provide the energy required to transfer the water from the WTP site to the recharge bores (via the existing 450 mm diameter pipeline from the Waikanae Borefield) and inject it into the aquifer. To avoid clogging the injection bores and aquifer with fine silt or clay particles there would need to be limits on the quality of water for reinjection [8]. There is a possibility that pH correction of the river water may be required prior to injection, and this has been allowed for in the risk-based cost estimates.

The concept design allows for replacement pumps and modifications to the existing abstraction bores to increase the flow delivered from each bore to meet the required yield. The power supply for each bore will also need to be upgraded. To maintain reasonable pipe velocities and minimise friction losses, a second pipeline will be laid adjacent to the existing. This pipeline must cross State Highway 1 and the North Island Main Trunk rail line en route to the WTP – these crossings would be constructed similar to the existing pipeline.

At this stage there is no allowance for additional treatment of the abstracted water other than the existing treatment process at the Waikanae WTP. This is based on the assumption that the abstracted water will be mostly river water that has not been in contact with the deep gravels for long enough to change in chemical composition. The appropriateness of this assumption can only be confirmed through further hydrogeological modelling work and with a full scale trial injection bore.

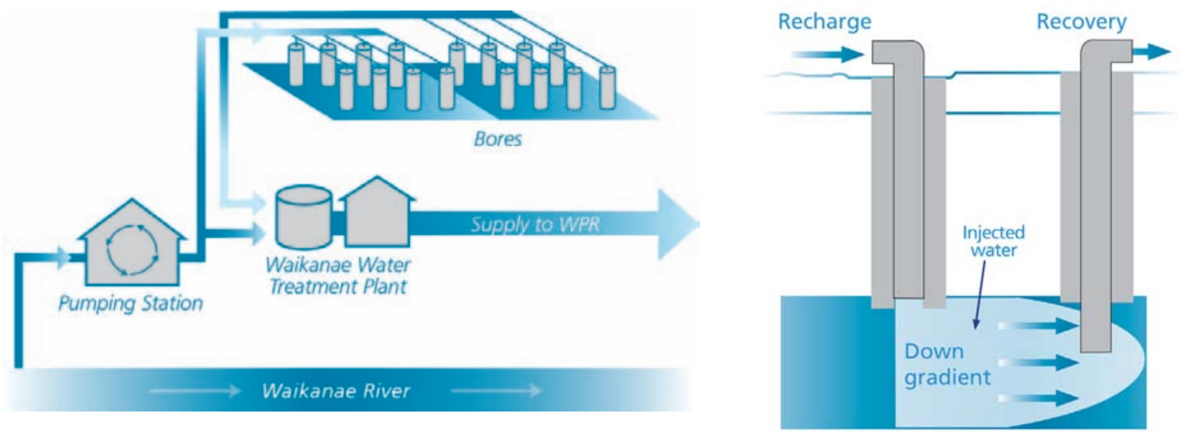


Figure 3.5: Aquifer Storage and Recovery Schematics

[8] *For example turbidity of less than 3 NTU (units of turbidity, which measures the 'dirtiness' of the water)*

Figure 3.6: Aquifer Storage and Recovery

In summary, the concept design includes:

- A flow splitting chamber and pump station at WTP site
- 5 recharge bores and feed pipeline connected to existing Waikanae Borefield pipeline
- Modifications to 4 existing bores – replace pumps, pipe modifications and power upgrade
- Connect bores Kb7 and K12 into the borefield
- One new abstraction bore including pump, pipework, monitoring wells and power supply
- Duplicate pipeline from Waikanae Borefield to WTP site.

The construction of the full ASR scheme could be staged to match demand, but this has not been considered in detail at this point in time.

3.3.3 Yield

The preliminary yield modelling showed that in the modelled 50 year drought with a required peak day yield of 32,000 m^3/day, the abstraction bores would be needed for up to about 140 days in a year and the longest continuous period of bore use would be about 60 days.

The modelling shows that approximately 1.7M m^3 of river water would need to be stored in the aquifer to meet demand in the modelled 50 year drought. This may require more than the core allocation of 26,000 m^3/day to be taken from the river during high flows in winter and spring for injection to the aquifer. This is consistent with the provisions in the Regional Freshwater Plan for flow harvesting and supplementary allocation.

3.3.4 Land

While the preferred location for any new bores is on Council land or road reserve, there are very few existing roads in the area indentified for recharge bores. The exact location of these bores will need to take into consideration the development plans for this area which is part of the Waikanae North Development Zone.

3.3.5 Environment

The key in-stream ecological issue relates to the impacts of flow harvesting and the reduction in winter and spring flows in the river. If this option were pursued, these investigations would be required. Few, if any, adverse terrestrial ecology effects are expected with this option. The pumping tests and modelling indicates limited impacts on the shallow unconfined aquifer.

3.3.6 Consultation

Although no fatal flaws have been raised in terms of landowner or stakeholder concerns, this option may not find the favour of the community due to being unfamiliar with the technique and there being a level of uncertainty around security of supply and water quality.

3.3.7 Cost Estimates

A breakdown of the base capital cost estimate for this option is $25.0 million (refer table below).

Table 3 3: Aquifer Storage and Recovery Capital Cost Estimate

	Cost
Fees & Investigation [3]	$2.65M
Land Value	$0.07M
Capital Cost	$15.38M
Design and Management [9]	$2.45M
Contingency (25%)	$4.46M
TOTAL	$25.0M

Overall O&M costs for this option are estimated at $1.38M/year increasing to $1.54M/year in 50 years

[4] *See page 13*

[9] *Includes an allowance for Council internal costs*



3.4 Option 4 – River Recharge with Groundwater

3.4.1 Concept

The main constraint to abstracting water from the Waikanae River during dry spells is the minimum flow level set in the Regional Freshwater Plan. The minimum flow is a method used to protect the ecology and amenity of the river – that is, it maintains the life-supporting capacity or general 'health' of the river. From time to time, river levels naturally fall below the minimum flow.

The River Recharge with Groundwater option involves abstracting groundwater from the Waikanae Borefield and discharging this to the Waikanae River, immediately downstream of the water supply intake to provide the minimum flow needs of the river. The groundwater discharge would bolster river flows downstream of the water treatment plant and thus enable more water to be taken from the river while maintaining the minimum flow.

Groundwater would only be discharged to the river when the natural river flow was at a level such that demand could not be met without going below the minimum river flow. Every additional litre abstracted from the river would be offset by a litre of groundwater discharged downstream. This effectively means the groundwater is feeding the river, while river water is being consumed. There are a number of spring-fed rivers in New Zealand, and in principle this option is similar.

The current Waikanae Borefield was designed to supply 23,000 m^3/day. Therefore, the borefield would need to be extended in order to meet the future peak yield of 32,000 m^3/day. Similarly, the resource consent for abstraction from the river would need to be modified (or a new consent sought) to increase the maximum daily groundwater take from 23,000 m^3/day to 32,000 m^3/day. The extension of the borefield is similar to that required for the Borefield and Treatment option. Like the Borefield and Treatment option, the construction of the full river recharge scheme could potentially be staged to match demand.

During the investigation phase, the groundwater model identified potential concerns relating to saline intrusion in the aquifers. In order to avoid this, the design approach was refined to include injection. In this summary report, the final proposed concept design is described.

The following schematic illustrates the concept of river recharge with groundwater:

3.4.2 Design

At the Waikanae WTP the river recharge groundwater will be discharged to the Waikanae River downstream of the WTP river intake.

To minimise the length of river in between the abstraction and recharge points, allowance has been made for a new discharge outfall pipe that would be positioned within the rock protection on the downstream face of the Waikanae WTP weir. This means that the discharge is located as close as possible to Waikanae WTP intake, whilst remaining downstream of the intake to avoid groundwater being put into supply. The discharge structure is designed to distribute the groundwater across the full width of the river to encourage mixing and dilution of the groundwater.

Further engineering work is needed to check the ability of the existing river intake and pump station to abstract sufficient water at low river levels. Also, because water is currently not taken from the river at low flows and low flows are relatively infrequent, the river water quality at these flows is not well understood. There will be no treatment of the groundwater prior to discharge to the river.

To mitigate risks around saline intrusion, allowance has been made for a new pump station at the Water Treatment Plant site to transfer river water to the Waikanae Borefield (via the existing pipeline) for recharging the aquifer. Three of the existing bores would be modified to enable them to be used for recharge as well as abstraction. Three new bores will also be added on an eastern pipeline roughly following SH1 to the north, while two additional bores will be connected by pipeline. Two existing bores (K10 and K13) will be taken out of service.

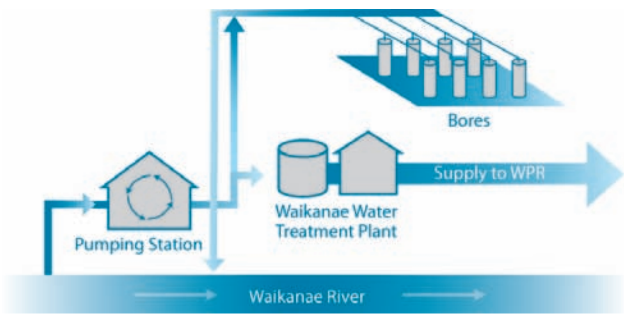


Figure 3.7: River Recharge with Groundwater Schematic

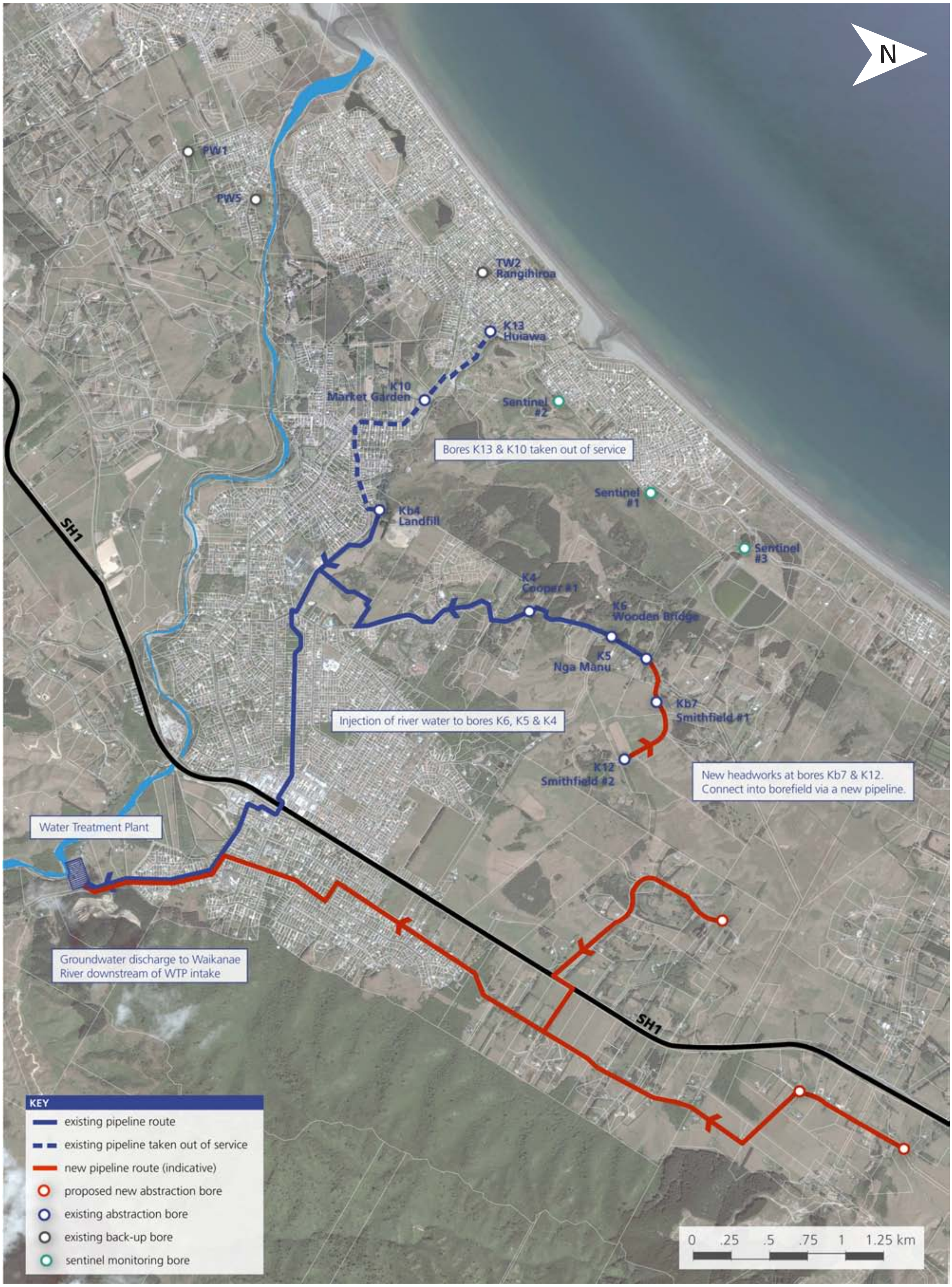


Figure 3.8: River Recharge with Groundwater

3.4.3 Yield

The yield modelling showed that in the modelled 50 year drought with a required peak day yield of 32,000 m^3/day, the bores would be needed for up to about 140 days in a year and the longest continuous period of groundwater discharge to the river would be about 60 days.

The groundwater modelling has shown that the saline intrusion is avoided if up to 10,000 m^3/day is injected into the aquifer for 5 months.

Under the worst-case design scenario of a 50 year low flow in the Waikanae River (517 L/s) and the 2060 peak day demand (32,000 m^3/day or 370 L/s), the flow downstream of the groundwater discharge would comprise 72% groundwater and 28% river water.

3.4.4 Environment

The main issue for this option includes changes to the water chemistry of the Waikanae River from the bore discharge, and potential effects of these changes on the river's ecology. The impacts of discharging bore water to the river were investigated by NIWA during the recent borefield pump testing. The key observations are summarised as follows:

- It is unlikely that the groundwater recharge option will have any adverse ecological effects on fish and invertebrates. This contention was able to be tested to a limited extent by the invertebrate sampling conducted in the Waikanae River mid way through the second bore pump test. No difference was found in any of the calculated biotic metrics at sites within the bore plume or at the upstream sites. This suggests that even within the plume, and before complete mixing has occurred, invertebrate communities were not responding in a demonstrable way to the discharge of bore water - at least in the short term (days to weeks). Also, no major differences in the fish communities at sites above and below the bore discharge point were found. The addition of injected river water to the aquifer may also further reduce the difference between the physical properties of the groundwater and river water, as some river water will be abstracted from the aquifer for river recharge
- Modelling showed that bore water augmentation to the Waikanae River would increase conductivity, alkalinity, hardness, pH, ammonium and dissolved reactive phosphorus (DRP). Concentrations of the latter approximately doubled within the mixing zone
- Increased DRP concentrations, when combined with stable low flows may result in undesirable periphyton growth in the mixing zone. Further tests would determine whether the algal communities in the river are nutrient limited (and in particular phosphorus limited)
- Complete mixing was observed after about 100 m. The mixing zone covers only a relatively small proportion of the river channel, and so it is unlikely that high algal blooms would occur in the remainder of the river outside the mixing zone. Localised increases in algal biomass are not considered to be a major issue. The proposed outlet structure would increase mixing at the discharge point.

In relation to flow harvesting during winter and spring for injection potential changes to the flow regime are likely to be small and unlikely to have any demonstrable adverse effects on the fish or invertebrate communities.

This option is unlikely to have adverse effects on terrestrial ecology. The groundwater modelling has shown that extended use of the aquifer will cause limited drawdown in the shallow aquifer, which allays concerns over potential adverse effects on wetlands and indigenous wet forest dependent on the aquifer.

3.4.5 Consultation

There are no apparent fatal flaws with this option, however it is probable that further detailed investigation will need to be undertaken into the environmental effects if it is preferred, particularly around the environmental effects of discharging groundwater into the Waikanae River. It appears that should the environmental effects assessment show that the adverse effects on the Waikanae River are no more than minor, this option may find the favour of the community, particularly in terms of cost and as a smart way to use existing infrastructure.

3.4.6 Cost Estimates

A breakdown of the base capital cost estimate for this option is $22.3 million (refer table below).

Table 3-4: River Recharge with Groundwater Capital Cost Estimate

	Cost
Fees & Investigation [4]	$2.65M
Land Value	$0.05M
Capital Cost	$13.41M
Design and Management	$2.21M
Contingency (25%)	$3.91M
TOTAL	$22.3M

Overall O&M costs for this option are estimated at $1.37M/year increasing to $1.52M/year in 50 years.

[4] See page 13

3.5 Composite Options

3.5.1 Purpose

In addition to the options considered in the preceding sections of the report, there are five further options that have been considered arising from composites of the short-listed options. The purpose in investigating composite options is to test whether, by combining or staging one or more of the short-listed options, better value for money can be delivered for the ratepayer.

Better value for money could for example be achieved by reducing any short term impacts of debt on Council's balance sheet by pushing capital expenditure further into the future (i.e. by staging); or by combining aspects of two or more options in such a way that the design requirements are still met but the capital costs are reduced.

In all cases that involve options that seek to delay capital expenditure, more specific yield modelling is required to determine how long the composite would be able to delay such expenditure while still meeting the design requirements. Five composite options have been developed over the course of Stage 3, and these are discussed in the Technical Analysis Report.

3.5.2 Composites with Merit

Ultimately only two composites were found to have merit, and both related to River Recharge with Groundwater. As Stage 3 has progressed, the River Recharge with Groundwater concept design was refined to address saline intrusion. The preferred means of managing saline intrusion risk was to inject river water into the existing wells – meaning the composite uses some of the best aspects of Aquifer Storage and Recovery (ASR), but without the riskier components of that option. That is, river water is taken during the winter and spring flows in the Waikanae River, and injected into the aquifer. During low river flows, groundwater is abstracted to provide flow to the river. However, unlike with ASR, whether or not river water is recovered from the aquifer is immaterial, as the water is being used for river recharge and not for consumption.

The second composite with River Recharge considered possible blending of the abstracted groundwater with river water. This option can be further explored as part of the preliminary design of River Recharge, should that option be identified as Council's preferred solution. Use of blending (in addition to the underground storage proposed as a result of river water injection) may assist in the consenting process with ecological impacts and also may improve drinking water quality during very low flows in the river (e.g. if/when algal blooms occur in the river).

3.6 Ōtaki River Source Comparison

3.6.1 Two Options

Based on Council policy, community feedback and a partnership approach to water management with tāngata whenua, the investigation of in-catchment options is the first priority before looking to out-of-catchment options. Council has set a goal for the Waikanae-Paraparaumu-Raumati (WPR) urban community to live sustainably within its own means, using the water supplied from within the Waikanae River catchment in conjunction with Council's water conservation initiatives – which includes a water conservation target of 400 litres/person/day.

However, for the purpose of comparison with the short-listed options, a consideration of cost for two Ōtaki River source options has been undertaken. These options are:

- The Ōtaki Wellfield and Pipeline option advanced to the consenting stage in 2001, but was abandoned when the consent application was declined – largely due to concerns raised by tāngata whenua. Many of the details from the preliminary design from this time, including the proposed preferred pipe route, have been carried over to the current cost estimate for this option. The base capital cost estimate for the Ōtaki Wellfield and Pipeline option is $37.8 million.
- The Ōtaki River Gorge transfer option was the second most favoured option arising from the multi-criteria analysis undertaken in Stage 2 of the project. A concept design was undertaken for this option to provide a basis for the base capital cost estimate. The base capital cost estimate for the Ōtaki River Gorge Transfer option is $32.7 million.

3.6.2 Comparison of Base Capital Cost Estimates

The following table provides a ranked summary of the four in-catchment options, as well as the two Ōtaki River source options. Ranking is based only on the base capital cost estimates. Later in the report, once the full range of other advantages and disadvantages are considered, a revised ranking is provided.

Rank ($)	Option	Base Capital Cost
1	River Recharge with Groundwater	$22.2 million
2	Aquifer Storage & Recovery	$25.0 million
3	Lower Maungakotukutuku	$27.9 million
4	Ōtaki River Gorge Transfer	$32.7 million
5	Borefield and Treatment	$34.3 million
6	Ōtaki Wellfield and Pipeline	$37.8 million

In addition to comparing these two Ōtaki options with the four in-catchment options as above, a review of the Ōtaki base capital cost estimate relative to earlier estimates has also been completed. Earlier estimates were significantly lower, in the range of $15-18M. However, these estimates excluded power supply upgrade, works at the Water Treatment Plant, plus a number of other costs, such as land purchase and design and management fees. Given the early stage of design, it is also prudent to include a contingency (which at this stage would typically be 25%). This was also not included in the earlier Ōtaki estimates.

While the cost estimates demonstrate that the Ōtaki River source options are more expensive than three of the in-catchment options, there are further concerns with this source option, including the following:

- A preliminary review of the Ōtaki River water resources was undertaken to confirm the available yield. This review required an understanding of the Regional Freshwater Plan, which establishes minimum flows on many rivers in the region, below which water may not be abstracted. In the case of the Ōtaki River, the minimum flow is set at a level below the 1 in 50 year drought flow, while that on the Waikanae is set between a 20 and 50 year drought. This effectively means the Waikanae River is better 'protected' than the Ōtaki River. While the conditions on the Ōtaki minimum flow rate are not as inflexible as for the Waikanae minimum flow, the effect of the flow regime established by the Regional Freshwater Plan, assuming the minimum flow is strictly interpreted and applied, is that the Ōtaki might not be able to provide full WPR supply by 2060 in a drought. Furthermore, the pipeline would not be able to supply any other users that Council may wish to also supply between Ōtaki and WPR.
- The Ōtaki Community Board and the tāngata whenua of Ōtaki have given their support for the investigation of in-catchment solutions as a first priority. However, it is clear that the Ōtaki Community Board, many in the wider Ōtaki community and tāngata whenua do not support the use of the Ōtaki River as a water supply source for the WPR area.

Accordingly, the Ōtaki River source options are not considered further.

Figure 3.9: Ōtaki River Source Options

3.7 Planning Issues

3.7.1 Preliminary Assessment

A preliminary planning assessment has been undertaken for the four options to consider consistency with regional and district planning documents, likely activity status and consenting issues. At this stage of investigation, all four options appear to sit comfortably with the objectives, policies and provisions of the regional and district planning documents. This assessment is subject to confirming that the environmental effects of any option chosen are acceptable at the consent application stage.

All technical investigations undertaken to date, and importantly those undertaken by NIWA around water quality and ecological effects, indicate that the environmental effects of the short-listed options are acceptable, and where necessary can be sufficiently mitigated. In addition, there are significant economic, social, health and well-being benefits to the community associated with providing water supply that sit well with the purpose and principles of the RMA. Each option has specific issues to be addressed in detail. The key issues are well understood at this stage, but will require further consideration by both GWRC and KCDC as set out as follows.

3.7.2 Regional Planning Requirements

- The Lower Maungakotukutuku Dam option will require resource consents from GWRC for damming and diverting watercourses and structures within the bed of a river. These will be assessed as a discretionary activity. These options will involve taking water from the Waikanae River at the WTP. Taking additional water above that consented will require an additional consent from GWRC and will be assessed as a discretionary activity
- The Waikanae Borefield and Treatment option will require resource consents as a discretionary activity for taking water from the Waikanae River. This option will require resource consents for abstraction above that already consenting by the existing resource consents, plus consents to inject river water into the aquifer during winter and spring
- The River Recharge with Groundwater option will require resource consents for the construction of new bores, taking groundwater, constructing a new discharge structure in the Waikanae River near the WTP and discharging the groundwater to the Waikanae River. These will be assessed as a discretionary activity. The Freshwater Regional Plan does provide for the discharge of water (in this case groundwater) to water as a permitted activity provided it meets a number of standards. Consents will also be required for taking additional water from the river during winter and spring for injection into the aquifer to mitigate saline intrusion risks. Taking additional water above that consented will require a consent from GWRC and will be assessed as a discretionary activity
- The Aquifer Storage and Recovery option will require resource consents for new abstraction bores and to inject surface water from the Waikanae River into the aquifer. These will be assessed as a discretionary activity. The diversion of groundwater (from injecting freshwater into the aquifer and displacing groundwater) should meet the permitted activity standards in the Freshwater Regional Plan and can therefore be considered a permitted activity. Taking additional water above that consented will require an additional consent from GWRC and will be assessed as a discretionary activity.

3.7.3 District Planning Requirements

All options will require resource consent for earthworks and vegetation clearance as a discretionary activity, unless works are required within the Open Space Zone in which case the activity status will be non-complying (potentially the ASR option). If Council seeks a Notice of Requirement to designate land for any of the options, the rules in the District Plan are not relevant. However, the District Plan rules are also a matter that Council needs to consider when assessing the Notice of Requirement. There are also a number of District Plan notations (e.g. Ecological Areas) which are relevant to both a Notice of Requirement or resource consents due to the potential effects on these values. The designation process (and associated Outline Plan process) will not completely exempt Council from restrictions on land use contained in section 9 of the RMA, or restrictions on air and water. Also, any designation will not apply to the beds of rivers. At this stage, it is recommended that Council consider using the designation provisions for the land associated with the Lower Maungakotukutuku Dam should this option be taken forward and also for pipes that are not located within the road reserve.

3.7.4 Conservation Covenant: Lower Maungakotukutuku Dam

An 18 ha area of land within the dam site (Lot 2 DP 360865) has been covenanted under the Reserves Act and is administered by the Department of Conservation (DoC). Approximately 4ha of covenanted land will be inundated by the dam. The environmental effects on the conservation value of this area and any potential mitigation measures will require careful consideration in close consultation with DoC. A number of mitigation measures have been identified in consultation with DoC, including provision of fish passage; off-setting by covenanting of an area of equivalent value and/or area of lowland forest that is currently unprotected; and restoration through riparian planting of an appropriate length of degraded streams within the Waikanae catchment.

3.7.5 Statutory Process

There are a number of options available for the statutory process. However the preferred option is a joint statutory process (involving the KCDC and GWRC) as provided under section 102 of the RMA. This will enable all aspects of the project (regional consents and district land use consents/NoR) to be considered as a whole, and avoid unnecessary duplication of work and resources. Given the scale of the project, it is likely that some approvals for the project (depending on how activities/consents are packaged) will be publically notified

4 Evaluation of Options

4.1 Risk-Based Capital Cost Estimates

Risk based cost estimates were developed in accordance with the requirements of NZTA's Cost Estimation Standard SM014 to Option Estimate standard. This is commonly applied as a standard by local government around New Zealand. For risk based estimates, this standard is also the one accepted by Treasury.

In addition to the construction base capital estimate, a risk register of project cost risks has been prepared and quantitatively analysed based on a correlated triangulation method where the best case and worst case inputs are deemed the 10th percentile and 90th percentile scenarios.

The following estimates or terms are therefore relevant in building up the risk based estimate:

- **Base Estimate:** The total sum of the elements that make up an estimate but not including a contingency.
- **Expected Estimate:** The Base Estimate plus an allowance for contingency based on the 50th percentile output from the risk analysis
- **Funding Risk:** An additional provision for known/unknown risk between the Expected and 90th Percentile Estimate. This is the basis on which Council is to make its 'funding' decision, and represents a prudent approach to financial management. Active management of risks through the next phases of the project aim to reduce the overall cost of delivering the project towards the expected estimate.

The estimated out turn costs of each of the four options are presented below:

Table 4-1: Risk-Based Cost Estimates

	Lower Maungakotukutuku Dam	Borefield & Treatment	Aquifer Storage & Recovery	River Recharge with Ground Water
Base Estimate	$23.1M	$28.0M	$20.6M	$18.3M
Expected Estimate – 50th Percentile	$28.6M	$34.1M	$24.8M	$21.9M
90th Percentile	$33.2M	$37.3M	$26.9M	$23.8M

4.2 Economic Analysis

As the future cash flows of capital and operation & maintenance costs of the different options vary over time, costs have been discounted to present values using the standard Treasury discount rate for infrastructure project of 8% real. The present value (PV) is a single figure for each option, where the lowest value indicates the most cost effective option. All the costs are in 2010 prices. More simply explained, the PV is the amount of money that would need to be set aside today, in order to construct, operate and maintain that option for the next 50 years. It provides Council with further economic information to enable comparative evaluation of options.

The PVs of the four options are presented in Figure 4-1. The PVs would be lowered by staging as this involves spreading the construction costs over a longer period of time in response to demand growing steadily over the 50 year period. Stageable options would have a positive impact on Council's overall budget over the 50 year period. In the event that an option that can be staged is chosen, one of the next steps would be to optimise staging.

Based on the analysis, Option 4: River Recharge with Groundwater is clearly preferred, having the lowest cost of all the options. In addition this option does not appear to create any significant adverse environmental effects (or effects on non-market values), and when compared with other options, this option does not cause greater concern than any of the other options.

The relative ranking of the options in purely cost terms does not change as a result of the PV analysis. However, the relative 'gap' between River Recharge and ASR (being the two lowest cost options) and the Lower Maungakotukutuku Dam is likely to widen with staging for either option, because the dam is not readily staged. In PV terms, River Recharge and ASR would therefore be likely to become even more favourable.

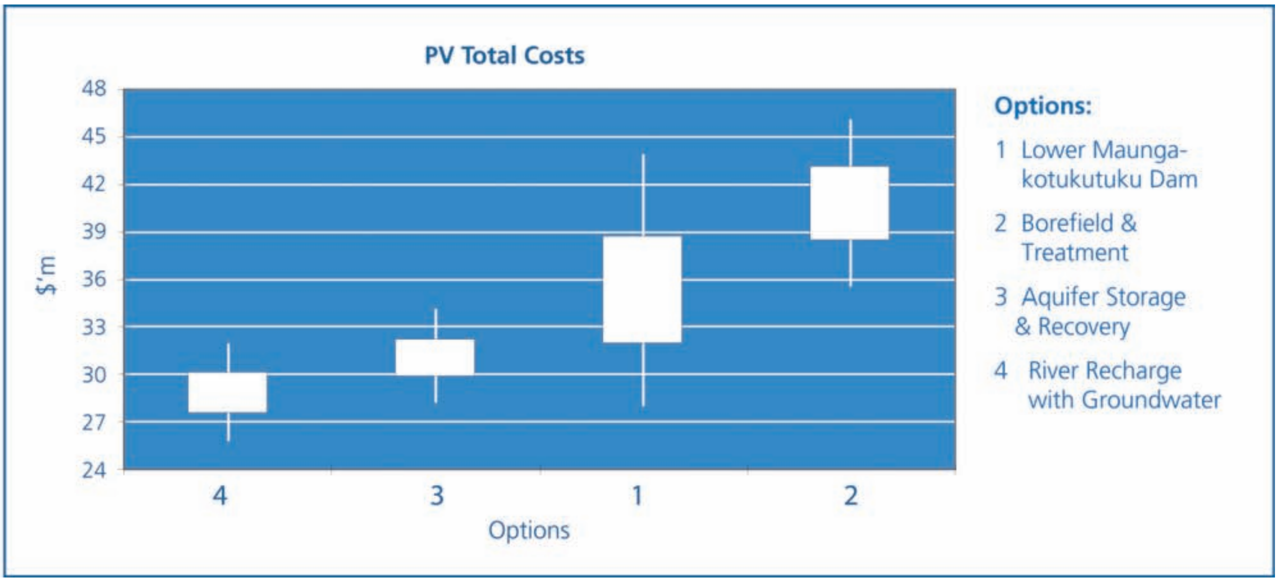


Figure 4.1: Summary of Risk Results (Box and Whisker Plot) [10]

[10] *The box shows the range at the 10% and 90% level of probability and the whiskers the maximum and minimum values*

4.3 Final Evaluation

A summary of the key advantages and disadvantages of the four options is presented in Table 4-2; categorised into cost, engineering, water quality, yield/security, environmental impacts, and social impacts/community acceptance.

Table 4-2: Summary of Key Advantages and Disadvantages of Options

Category	Advantages	Disadvantages
Option 1: Lower Maungakotukutuku		
Cost	Could provide opportunity for micro-hydro generation to offset some costs.	Second most expensive in both capital and PV.
Engineering	Site confirmed as providing suitable foundation for the dam.	
Water Quality	Taste and hardness matches existing river supply.	Potential for algal bloom, particularly in shallower areas, could add to management complexity.
Yield/Security	Greater level of certainty compared with groundwater options.	
Environmental Impacts	Creation of lake habitat which will favour trout, giant kokopu and eels. No threatened plant species identified. Adverse environmental effects are considered to be minor, and able to be sufficiently managed.	Displacement of redfin bullies, torrent fish and koaro, as well as river invertebrates. Fish passage for native fish disrupted (can be mitigated). Loss of 5.23 ha of high value ecological forest. Loss of indigenous terrestrial fauna habitat. Potential edge effects to remaining forest (mitigated by planting). Dam site is located within a conservation covenanted area.
Social Impacts/ Community Acceptance	Two main landowners are both generally supportive. Concept of a dam as a water supply solution appears to have general support in the community. Dam also has potential recreational value, in particular if a larger dam is constructed.	Some general community concern regarding dam break risk and environmental effects of damming stream.
Option 2: Borefield & Treatment		
Cost	PV can be reduced by staging.	Highest capital cost and PV.
Engineering	Borefield extension and nanofiltration treatment can be staged to meet demand growth.	Uncertainty about additional bores.
Water Quality	Improvement on taste and hardness of existing borefield supply.	Taste and hardness greater than existing river supply (but less than existing borefield).
Yield/Security	Increased flexibility from having two separate raw water sources.	Risks of unknown geology to the northeast of the existing borefield for new bores. Requirement for additional water to account for losses through treatment process.
Environmental Impacts	New bores and pipelines can be sited to avoid ecologically significant areas. Limited drawdown effects on the shallow aquifer.	Requires disposal of up to about 3,300 m^3/day of brackish water. Impacts of this uncertain and not investigated.
Social Impacts/ Community Acceptance		General reluctance by many to continue to rely on the borefield for potable water supply due to history of water quality issues. Disruption during construction to urban areas (including parks etc).

Category	Advantages	Disadvantages
Option 3: Aquifer Storage and Recovery		
Cost	Second lowest cost in terms of capital and NPV. PV can be reduced by staging.	
Engineering	Borefield extension can be staged to meet demand growth.	Need trial well to demonstrate feasibility. River water may require pH correction prior to reinjection.
Water Quality	Likely improvement on taste and hardness of existing borefield supply.	Taste and hardness greater than existing river supply (but expected to be less than existing borefield supply).
Yield/Security	Some additional flexibility from having additional underground storage. Can be designed to minimise risk of saline intrusion.	Risks around unknown geology to the east of the existing borefield for new injection bores.
Environmental Impacts	Very limited drawdown effects on the shallow aquifer, and may be enhanced during injection periods.	
Social Impacts/ Community Acceptance	New infrastructure located within road reserve/ Council-owned land. Overall a minor impact on landowners and minor social impact from construction and ongoing operation.	Reluctance by many to continue to rely on the borefield. May not find favour due to lack of understanding of concept of ASR – need for clear explanation. Disruption during construction to urban areas (including parks etc).
Option 4: River Recharge with Groundwater		
Cost	Lowest capital cost and PV. PV can possibly be reduced further via staging review	
Engineering	Borefield extension can be staged to meet demand growth.	
Water Quality	Uses river water, so will match existing water supply taste.	
Yield/Security	Increased flexibility from using two separate raw water sources, albeit only one water source used for drinking purposes.	Risks around unknown geology to the northeast of the existing borefield.
Environmental Impacts	Limited drawdown effect on the shallow aquifer. Very minor adverse in-stream ecological effects. Potentially reduced further by injection of river water into aquifer.	Possible adverse effects from nutrients (mainly phosphorus) in groundwater recharge to river. This needs to be investigated further. Use of injection will possibly reduce this concern further.
Social Impacts/ Community Acceptance	Use of existing infrastructure. No significant concerns expressed regarding this option. If no adverse effects on the Waikanae River are confirmed, this option may find favour in the community.	Disruption during construction to urban areas (including parks etc). Time taken for rehabilitation to occur.

If we consider the advantages and disadvantages summarised in Table 4-2, and compare the dam option against the groundwater options, the following is clear:

- The dam option is more expensive in capital cost than all but one of the groundwater options
- The dam option provides more long term certainty around yield than the groundwater options
- Only the dam option and River Recharge with Groundwater will match the taste and hardness of the existing river supply
- The environmental effects associated with the dam are greater than those for the groundwater options, but the effects are considered able to be sufficiently avoided, remedied or mitigated
- The dam option has general support in the community, but only one of the groundwater options (River Recharge with Groundwater) is likely to have general community acceptance
- Aquifer storage and recovery and the extended borefield and treatment options involve drinking water from the aquifer, which are likely to require a change in attitudes to drinking groundwater.

4.4 Composites

As outlined in Section 3.5, although a number of composite options have been conceived, only two have advantages that outweigh the disadvantages:

- River Recharge with Groundwater & Blending of Groundwater
- Aquifer Storage and Recovery and River Recharge.

Prior to the refinement of the River Recharge option to require the injection of soft river water into the bores closest to the coast, these composites provided benefits that differed to the core options. However, it is considered that the composites have contributed to the improvement of the River Recharge approach, and that final option now reflects the best of a number of the options without any of the disbenefits.

5 Ranking and Recommendations

5.1 Ranked Options

The assessment and ranking of options has included consideration of the key issues of yield and security of supply, water quality and their capital and PV costs, as well as the full range of advantages and disadvantages presented earlier in this report. Our final assessment of the ranking of the four options is presented in Table 5-1.

Table 5-1: Ranked Options

Rank	Option
1	River Recharge with Groundwater
2	Lower Maungakotukutuku Dam
3	Aquifer Storage and Recovery
4	Borefield and Treatment

5.2 Conclusions and Recommendations – Preferred Solution

Given the extensive process to evaluate options undertaken to date, the recommendations in this report build on each other. While there are four in-catchment options under consideration, the report also provides a comparable cost estimate for the two most highly favoured Ōtaki River options. It is therefore important that our recommendations reflect the extensive process.

5.2.1 In-Catchment Solutions

The first key conclusion is that in-catchment solutions are available to resolve Council's long term water supply requirements for the WPR area. However, while all four options provide for the yield, security and water quality specified in the design requirements, they are not all equal. For instance, there is a significant spread of overall cost, and the risk profiles of each option also differ markedly.

On the basis of the ranked options list, two options are identified as being less optimal. That is, Aquifer Storage and Recovery and Borefield and Treatment. Each of these is considered below:

- Aquifer Storage and Recovery is without doubt an innovative solution. It essentially involves storing water in the aquifer in winter and spring for use during summer. The key concerns are that this is not a technology that has been used in New Zealand before to the best of our knowledge, although it is relatively common internationally (particularly in Australia and USA).
  There are a number of risks associated with being a New Zealand first and early adopters of technology. One key uncertainty is the as yet unproven ability to recover soft river water from the aquifer for drinking. This option may also encounter perception problems with the community in terms of drinking bore water, although that is not a primary concern that has influenced our recommendation. In addition, it is more expensive than the River Recharge option.
- However, while ASR is not recommended for further consideration, the benefits of this approach have been included in part in the refined concept for River Recharge with Groundwater. The River Recharge option now requires the injection of soft river water into the aquifer to manage saline intrusion risk. While this refined approach does involve underground storage and recovery of water, the key differences between this and ASR are that the need to fully recover the river water for drinking disappears – and with it, a significant number of risks and uncertainties. Of course, in the event river water is recovered, because it is being used to recharge the minimum flow of the river, it will further lessen the already minor ecological effects on the Waikanae River downstream from the current intake. Overall, the principle of river water injection to the aquifer can be applied to River Recharge option to get a better end result.
- Borefield and Treatment is a relatively simple option to dismiss. At over $37M, it is simply too expensive. Furthermore, it is the one option that involves continuing to drink bore water, albeit that there would be enhanced treatment. Based on our extensive community consultation carried out over the past nine months, this option may have difficulty gaining the support of the public.

Recommendation 1:
Eliminate two options

That Council eliminate Aquifer Storage and Recovery and Borefield and Treatment Options from further consideration due to:

- In the case of ASR, risk and uncertainty in relation to the ability to recover sufficient river water from the aquifer for drinking and the relative untested nature of the approach in New Zealand
- In the case of the Borefield and Treatment option, cost that is over Council's allocated budget.

5.2.2 Preferred solution

This leaves two potential options:

- Lower Maungakotukutuku Dam
- River Recharge with Groundwater (modified to include injection).

In developing our final recommendation on the preferred solution, we have considered key issues such as:

- Engineering and design issues
- Water quality
- Yield and security
- Environmental impacts
- Social impacts and likely community acceptance
- Risk
- Cost.

Overall, this analysis leads us to conclude that River Recharge with Groundwater provides the most sustainable, consentable, and cost effective solution. This option is preferred due to:

- This option being the lowest cost option
- Providing the greatest benefit in terms of staging and future flexibility
- Has the least environmental impacts and best mix of benefits of all the shortlisted options
- Will provide a water quality to consumers that they are already satisfied with (that is, soft Waikanae River water).

Before this option is recommended, it is important to note the next steps that are seen as being critical to this recommendation. The next steps include:

- Preparing an Assessment of Environmental Effects / Resource Consents, and liaising with Greater Wellington Regional Council to discuss a range of issues in advance of any eventual application by KCDC
- Stakeholder consultation
- Implementing a specific monitoring program in the short term to gather further data on the interface between the freshwater aquifers and salt water to enable better management of saline intrusion risks. This will include drilling (or using existing) a series of deep and shallow wells near the coast to monitor conductivity (saline intrusion)
- Further pumping tests of existing wells
- Limited further 3D groundwater modelling to confirm (or further refine) the design and to support AEE
- Drill and test new wells required as part of the extension of the borefield to confirm feasibility and yield
- Work out staging more definitively to optimise the benefits of managing cashflow over the 50 year period.

Recommendation 2: Preferred Solution

That Council proceed with River Recharge with Groundwater as the preferred solution and undertake the following steps to confirm the feasibility of this option:

- Establish a monitoring program to establish the existing salt and freshwater boundary in the aquifer, and to monitor for signs of saline intrusion
- Drill test wells for the three new bores that need to be added to the overall scheme
- Further pumping tests of existing wells
- Optimise the approach to staging
- Complete the investigations and stakeholder consultation.

It is noted that not all of the above are likely to be required in order to complete the resource consent applications, but should be required to satisfy Council before proceeding with construction of this option.

During these further investigations, there remains a possibility or risk that further knowledge gained from testing and modeling outlined above causes the River Recharge with Groundwater option to become unfeasible or unconsentable. While this is considered unlikely, if investigations fail to confirm feasibility, then Council should proceed with the Lower Maungakotukutuku Dam option as the next preferred solution.

5.2.3 Future-Proofing

During the course of preparing our recommendations, it became clear that Council has a further opportunity to consider water supply planning over a much longer term period than this project has to date been examining. That is, while the recommendation to proceed with River Recharge will provide up to 50 years of supply, the future WPR community will need to identify additional supply for the 50 years beyond that.

Given that investigations carried out over the course of this project into all options have been extensive, and the two most cost-effective solutions have been identified, we consider it unlikely the relative merits of other options will change in future (without significant changes in circumstances e.g. changes to minimum flow regimes, technology etc).

It is highly likely that a future Council will be faced with an equally challenging task of identifying and securing access to a new water source for the WPR area (or indeed the wider community as it exists at that time) for that 50-100 year period. By that time, unless options for providing water in 50-100 years time are protected now, they would have been lost or foreclosed. Given that the two best and most cost effective options have been identified through this extensive process, if the next preferred option – being the Lower Maungakotukutuku Dam – is not protected in some form, inevitably any other future WPR supply option will be more difficult and expensive. Therefore, it is our recommendation that Council consider the merits of future-proofing the WPR water supply for 50-100 years.The estimated short term cost is between $1.3M and $2M. However, this figure would need to be confirmed through negotiations with landowners and other stakeholders. Specifically, there would be a series of short term costs associated with securing the site, and removal of the covenant. Then, longer term costs associated with construction of the dam would be incurred well into the future – in approximately 50 years time if design assumptions are correct.

Recommendation 3: Future-Proofing WPR Water Supply

That Council future-proof the WPR water supply for the long term (e.g. 50-100 years) by:

- Securing an option to buy land in the short term for the Lower Maungakotukutuku Dam site
- Resolving the covenant on the site (i.e. through mitigation and discussion with DoC)
- If successful with above, exercise option to buy and purchase land
- Signal the long-term intention to develop a dam on the site (i.e. in the District Plan).

5.2.4 Ōtaki River

Given that the preferred solution and also the future-proofing are lower cost than either of the Ōtaki River supply options, combined with the possible inability of the Ōtaki to supply the yield required, it is clear that there would be an unwarranted cost premium for using Ōtaki water. Furthermore, the option of sourcing water for the WPR area from the Ōtaki River remains unpopular with many in the Ōtaki community, and would likely be difficult to consent.

Recommendation 4: Ōtaki

That Council reject all options to supply WPR from the Ōtaki River source, due to:

- Base capital costs for the two favoured Ōtaki River options being higher than for other acceptable in-catchment solutions
- Concerns regarding the ability to secure the required volume of water under the minimum flow regime
- Community and tāngata whenua opposition to abstracting Ōtaki River water for the WPR supply.